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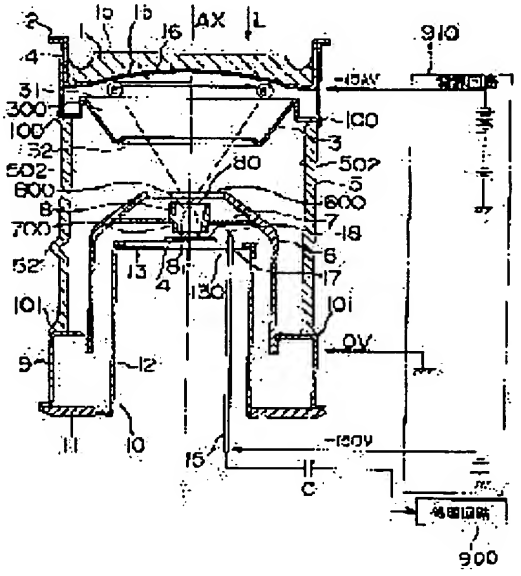
## (54) ELECTRON TUBE

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain such a structure that can stabilize the orbit of electron accelerated and focused by an electronic lens and effectively suppress the generation of noises due to discharging.
SOLUTION: A cathode electrode 3 constituting an electronic lens extends partly toward a stem 10 along an inner wall 502 of an insulation container 5 and its tip end becomes thinner toward the stem 10, so that the tip end of the electrode 3 is apart from the inner wall 502 of the container 5. Thus, the container 5 is prevented from charging, and the discharging together with light emission to the electrode 3 and the container 5 can be suppressed.

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CLAIMS

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[Claim(s)]
[Claim 1] The container which consists of an insulating ingredient which has the 1st opening, this 1st opening, and the 2nd opening located in the opposite side, The photoelectric surface for being located in a 1st [ of said insulating container ] opening side, and emitting a photoelectron corresponding to the light by which incidence was carried out, The stem for being located in a 2nd [ of said insulating container ] opening side, and specifying the distance of said photoelectric surface and the electronic plane of incidence which the photoelectron emitted from this photoelectric surface reaches, While accelerating the photoelectron which was prepared in the space between said photoelectric surfaces and said stems, and was emitted from this photoelectric surface In the electron tube equipped with the electron lens for completing the orbit of this photoelectron said electron lens The cathode electrode which has a through tube for passing the emitted photoelectron toward said electronic plane of incidence from said photoelectric surface, and has the configuration where the part was prolonged toward said stem in accordance with the wall of said insulating container, It is the electron tube which is equipped with the anode electrode which has opening for passing this cathode electrode and the passed photoelectron toward this electronic plane of incidence, and is characterized by the cross section of said through tube in said cathode electrode being small toward said photoelectric surface to said stem further.
[Claim 2] The container which consists of an insulating ingredient which has the 1st opening, this 1st opening, and the 2nd opening located in the opposite side, While having the photoelectric surface for being located in a 1st [ of said insulating container ] opening side, and emitting a photoelectron corresponding to the light by which incidence was carried out, and the electronic plane of incidence which the photoelectron emitted from said photoelectric surface reaches The semiconductor device arranged so that this electronic plane of incidence may counter with said photoelectric surface, The stem for being located in a 2nd [ of said insulating container ] opening side, and specifying the distance of said photoelectric surface and electronic plane of incidence of said semiconductor device, While accelerating the photoelectron which was prepared in the space between said photoelectric surfaces and said stems, and was emitted from this photoelectric surface In the electron tube equipped with the electron lens for completing the orbit of this photoelectron said electron lens The cathode electrode which has a through tube for passing the emitted photoelectron toward said semiconductor device from said photoelectric surface, and has the configuration where the part was prolonged toward said stem in accordance with the wall of said insulating container, It is the electron tube which is equipped with the anode electrode which has opening for passing this cathode electrode and the passed photoelectron toward this semiconductor device, and is characterized by the cross section of said through tube in said cathode electrode being small toward said photoelectric surface to said stem further.
[Claim 3] Stem side opening of said through tube [ in / the part prolonged toward said stem of said cathode electrode is contained in the building envelope of this insulating container defined by the 1st and 2nd openings of said insulating container, and / this cathode electrode ] is the electron tube according to claim 1 or 2 characterized by being located in the building envelope of this insulating container.
[Claim 4] Said cathode electrode is the electron tube of claim 1-3 characterized by bending a part for the point prolonged in said stem side inside with predetermined curvature given in any 1 term.
[Claim 5] Both openings of stem side opening of the through tube in said cathode electrode while said anode electrode has the configuration where the part was prolonged toward said photoelectric surface in accordance with the wall of said insulating container, and said anode electrode are the electron tube of claim 1-4 characterized by being located in the building envelope of this insulating container defined by said 1st and 2nd openings of said insulating container given in any 1 term.
[Claim 6] The electron tube of claim 1-5 characterized by having a collimator electrode for being the

electrode contained by this anode electrode while having the through tube prolonged toward said photoelectric surface to said stem for passing the photoelectron which passed opening of said anode electrode, and correcting the orbit of the photoelectron by which incidence was carried out to this through tube given in any 1 term.

[Claim 7] The cross section of said through tube in said collimator electrode is the electron tube according to claim 6 characterized by being small toward said stem from said photoelectric surface.

[Claim 8] The area of stem side opening of said through tube in said collimator electrode is the electron tube according to claim 6 or 7 characterized by being smaller than said electronic plane of incidence.

[Claim 9] The electron tube of claim 6-8 characterized by having the shield which has opening for contacting an anode electrode and directly [ said ] and holding said collimator electrode to the position in this anode electrode given in any 1 term.

[Claim 10] The area of said opening in said shield is the electron tube according to claim 9 characterized by being smaller than the area of photoelectric-surface side opening of said through tube in said collimator electrode, and being larger than the area of stem side opening of said through tube in this collimator electrode.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the electron tube equipped with the sensing device for detection etc. to carry out the photoelectron especially emitted from the photoelectric surface and this photoelectric surface about the photodetector for measuring a feeble light quantitatively.
[0002]
[Description of the Prior Art] Conventionally, the electron tube which accelerates and converges the photoelectron emitted from the photoelectric surface with an electron lens, and carries out incidence to a semiconductor device by using this photoelectron as a sensing device, for example, acquires high gain is known. This conventional electron tube For example, JP,6-318447,A, JP,5-54849,A, JP,7-320681,A, Or G.A.Johansen and "Operational characteristics of an electron-bombarded silicon-diode photomultiplier It is indicated by tube", Nuclear Instruments and Methods in Physics Research A326 (1993), p.295-298, etc.
[0003] Especially, the electron lens constituted with the plate electrode which has opening for a photoelectron to pass is indicated by above-mentioned JP,6-318447,A and JP,7-320681,A. The electron lens constituted with the cylindrical electrode which has opening for a photoelectron to pass in above-mentioned JP,5-54849,A and Johansen reference on the other hand is indicated.
[0004]
[Problem(s) to be Solved by the Invention] As mentioned above, in the case of the electron tube with which the electron lens consists of plate-like electrodes, the wall of the container which consists of an insulating ingredient serves as structure exposed to the photoelectron which runs the inside of a vacuum. Therefore, in the electron tube of such structure, an electron orbit is disturbed by electrification of the bulb wall by the stray electron, and the technical problem that a stable output is not obtained occurs.
[0005] Furthermore, as for the case of the electron tube with which the electron lens consists of cylindrical electrodes, pressure-proofing poses a problem as mentioned above. That is, if the electrical potential difference impressed to the photoelectric surface exceeds about -7kV, intermittent discharge will generate such the electron tube. The light produced by that discharge passes the path of arbitration in many cases with luminescence, and this discharge generates return and a false signal (noise) in the photoelectric surface. This false signal has the technical problem that S/N at the time of feeble light measurement is reduced remarkably.
[0006] Especially, as a sensing device, if the electrical potential difference impressed to this photoelectric surface is set to a plus side from -6kV in the case of the electron tube equipped with the semiconductor device which carries out multiplication of the photoelectron emitted from the photoelectric surface, while reducing the possibility of above-mentioned discharge, it will result in running short of the gain of the semiconductor device concerned. This originates in the property of the electron tube that the energy of the incidence electron to a semiconductor device is changed into gain and of having a semiconductor device, and is not avoided.
[0007] If reference is furthermore made and the insulating container will be directly exposed to an electron orbit even if an electron lens is cylindrical, when this insulating container is charged, the electron orbit itself will be made unstable.
[0008] While this invention stabilizes the orbit of the electron which it accelerated and converged with the electron lens, having been made in order to solve the above technical problems, impressing the electrical potential difference of about -15kV to the photoelectric surface, and maintaining high gain, it aims at offering the electron tube equipped with structure effective in control of noise generating by above-mentioned discharge.

[0009]
[Means for Solving the Problem] The container with which the electron tube concerning this invention consists of an insulating ingredient which has the 1st opening, this 1st opening, and the 2nd opening located in the opposite side, The photoelectric surface for being located in a 1st [ of this insulating container ] opening side, and emitting a photoelectron corresponding to the light by which incidence was carried out, The stem for being located in a 2nd [ of an insulating container ] opening side, and specifying the distance of the photoelectric surface and the electronic plane of incidence which the photoelectron emitted from this photoelectric surface reaches, It is prepared in the space between the photoelectric surface and a stem, and while accelerating the photoelectron emitted from this photoelectric surface, it has an electron lens for completing the orbit of this photoelectron.
[0010] In addition, the above-mentioned electronic plane of incidence is the plane of incidence of a sensing device for detection etc. to carry out the photoelectron emitted from the photoelectric surface, for example, is equivalent to the electronic plane of incidence of semiconductor devices, such as an avalanche photo-diode which carries out multiplication (the energy of this electron is changed into gain) of the photoelectron emitted from the photoelectric surface. Moreover, in the electron tube concerned, the above-mentioned electron lens consists of a cathode electrode which has a through tube for passing at least the photoelectron emitted from the photoelectric surface toward electronic plane of incidence, and an anode electrode which has opening for passing the photoelectron which passed this cathode electrode toward this electronic plane of incidence.
[0011] Especially the cathode electrode in the above-mentioned electron lens has the configuration where the part was prolonged toward the stem in accordance with the wall of an insulating container. And that the fault resulting from electrification of the above-mentioned insulating container should be avoided, the cross section (area of this through tube defined by the perpendicular field to the direction of a tube axis) of the through tube in this cathode electrode is small toward this photoelectric surface to this stem so that this cathode electrode may estrange from the wall of an insulating container toward the photoelectric surface to the stem. If it puts in another way, the area of stem side opening of the through tube in this cathode electrode is set up smaller than the area of photoelectric-surface side opening of the through tube in this cathode electrode. Furthermore, a part for the point of the above-mentioned cathode electrode (stem side of the cathode electrode concerned) is bent inside with predetermined curvature.
[0012] Furthermore, the above-mentioned anode electrode in the electron tube concerning this invention has the configuration where that part was prolonged toward the photoelectric surface in accordance with the wall of an insulating container. And both openings of stem side opening of the through tube in the above-mentioned cathode electrode and an anode electrode are located in the building envelope of this insulating container defined by the 1st and 2nd openings of an insulating container. That is, the above-mentioned cathode electrode has the configuration projected toward the anode electrode, and the above-mentioned anode electrode has the configuration projected toward the cathode electrode. If it puts in another way, the electron tube concerned consists of cathode electrodes by realizing structure which brought this cathode electrode and the anode electrode close from a viewpoint of stabilization of the output current so that the wall of the above-mentioned insulating container directly exposed to the electron which faces to an anode electrode may become the minimum.
[0013] Furthermore, the electron tube concerning this invention is the electrode contained by this anode electrode while having the through tube prolonged toward the photoelectric surface to the stem for passing the photoelectron which passed opening of the above-mentioned anode electrode further, and is equipped with the collimator electrode for correcting the orbit of the photoelectron by which incidence was carried out to this through tube. This collimator electrode functions as correcting the orbit of this electron so that the electron emitted from the photoelectric surface may carry out incidence perpendicularly to the electronic plane of incidence of an above-mentioned semiconductor device. It is for maintaining the high discrimination capacity of the electron number in the electron tube concerned. Furthermore, from the photoelectric surface, that cross section (area of this through tube defined by the perpendicular flat surface to the direction of a tube axis) is formed so that it may become small toward a stem, so that the through tube of this collimator electrode may raise this function.
[0014] When reference is made about the relation on the structure of the above-mentioned collimator electrode and the above-mentioned electronic plane of incidence, the area of stem side opening of the through tube in this collimator electrode is smaller than this electronic plane of incidence. That is, the service area of this electronic plane of incidence in which the electron adjusted by the collimator electrode carries out incidence perpendicularly becomes smaller than the area of this electronic plane of incidence.

This is because it is necessary to prevent unnecessary electrification while avoiding the collision of the electron which reaches in addition to the above-mentioned electronic plane of incidence from a viewpoint of component protection.

[0015] The electron tube concerning this invention is further equipped with the metal shield which has opening holding this collimator electrode that the above-mentioned collimator electrode should be fixed to the predetermined location in the above-mentioned anode electrode. This shield also functions that advance of electrons other than the above-mentioned electronic plane of incidence should be prevented. Moreover, it is directly fixed to the wall of an anode electrode, and this shield is supporting the collimator electrode directly by that opening. According to this structure, the above-mentioned anode electrode and a collimator electrode are set as this potential. Furthermore, the area of opening in this shield is it is smaller than the area of photoelectric-surface side opening of the through tube in this collimator electrode, and larger than the area of stem side opening of the through tube in this collimator electrode in order to support a collimator electrode directly.

[0016]

[Embodiment of the Invention] Hereafter, the example of the electron tube concerning this invention is explained using drawing 1 - drawing 10 . In addition, the same sign is given to a same-among drawing part, and explanation is omitted. Moreover, this example explains the electron tube equipped with the semiconductor device which carries out multiplication of the electron by which incidence was carried out from this electronic plane of incidence as a sensing device which has the electronic plane of incidence which the photoelectron emitted from the photoelectric surface reaches. The electron tube equipped with this semiconductor device is effective as a photodetector for measuring quantitatively about 10 per one event, and a very feeble light.

[0017] In this drawing, that overall length of the insulating container 5 is the glass bulb of the cylinder hollow 24mm and whose diameter of those are about 25mm. And welding of the cylindrical shape-like the flange 4 and flange 9 of covar metal with a height of about 3.5mm is carried out to each by the side of the 1st opening 500 of this insulating container 5, and the 2nd opening 501. Moreover, the feed pipe 50 for carrying out evacuation of this container 5 to the side attachment wall of the glass bulb 5, and pouring in the metallic fumes for photoelectric-surface formation is formed.

[0018] The input face-plate 1 is the glass plate 1 which has 2nd page 1b of a configuration which was located in 1st page 1a which was processed evenly, and which is located in the incidence side of light, this 1st page 1a, and the opposite side, and turned the concave surface to the stem 10. Welding of this glass plate 1 is carried out to the flange 2 of covar metal, and welding immobilization of this flange 2 is carried out further at the flange 4 by which welding was carried out to the above-mentioned glass bulb 5. Behind, on 2nd page 1b of the above-mentioned glass plate 1, the photoelectric surface 16 with an effective diameter of 16mm is formed.

[0019] Welding immobilization of the stem 10 of covar metal for on the other hand specifying the distance of the photoelectric surface 16 and a semiconductor device 14 (electronic plane of incidence) to the flange 9 by which welding was carried out to the above-mentioned glass bulb 5 is carried out. This stem 10 consists of members 11, 12, and 13, and that central part is the cross-section convex configuration projected to the photoelectric-surface side. In addition, the above-mentioned semiconductor device 14 is carried in the field by the side of the photoelectric surface of the member 13 which constitutes this stem 10, and the lead pin 15 is being fixed through the through tube 130 prepared in this member 13.

[0020] In the container constituted as mentioned above, while accelerating the photoelectron emitted from this photoelectric surface 16 in the space between this photoelectric surface 16 (glass plate 1) and a stem 10, the electron lens for completing the orbit of this electron is prepared. This electron lens is constituted from a cathode electrode 3 made from stainless steel by which welding immobilization was carried out, and an anode electrode 6 made from stainless steel set as potential higher than this cathode electrode 3 by the above-mentioned flange 4 at least. The cathode electrode 3 has the configuration projected to this stem side while having the through tube 300 penetrated toward the stem 10 from the glass plate 1. Moreover, the anode electrode 6 has the shape of a cylindrical shape in the air projected toward this cathode electrode 3 while having the opening 600 for passing further the electron which passed this cathode electrode 3. Welding immobilization of this anode electrode 6 is carried out at the flange 9 by which welding was carried out to the above-mentioned glass bulb 5.

[0021] Furthermore, in the above-mentioned anode electrode 6, the collimator electrode 8 made from stainless steel for correcting the orbit of this electron is formed so that the electron which passed the opening 600 of the anode electrode 6 may carry out incidence at right angles to the electronic plane of incidence of

the above-mentioned semiconductor device 14. The through tube 800 for passing this electron toward a semiconductor device 14 is formed in this collimator electrode 8, and this collimator electrode 8 is being further fixed to the predetermined location in the anode electrode 6 by the metal shield 7.
[0022] The above each part material constitutes the well-closed container maintained by the vacua in the interior of a container concerned along the direction AX of a tube axis of the glass bulb 5 by being attached in the 1st opening [ of this glass bulb 5 ] 500, and 2nd opening 501 side, respectively, as shown in drawing 1 .
[0023] some well-closed containers constituted as mentioned above -- a fracture perspective view is shown in drawing 2 . The photoelectric surface 16 is in the condition which made the inside of a container the vacuum through the through tube 51 of a feed pipe 50. The metallic fumes of K (potassium), Na (sodium), and Cs (caesium) are poured in in order through this through tube 51. It is formed as a field with an effective diameter of about 16mm by making it react with Sb (antimony) beforehand deposited on 2nd page 1b by making each [ these ] metal deposit in order on 2nd page 1b of a glass plate 1. In addition, while these metals heat the whole tubing, 2nd page 1b can be made to vapor-deposit them alternatively by maintaining this glass plate 1 at low temperature a little. And that the inside of this well-closed container should be held to a vacua, if the photoelectric surface 16 is formed as mentioned above, as shown in drawing 3 , it will cut so that the through tube 51 of a feed pipe 50 may be closed. In addition, 52 are some cut feed pipes 50 among drawing. Moreover, drawing 4 is the sectional view in alignment with D-D line in drawing 2 after the feed pipe 50 was cut (after the photoelectric surface 16 was formed) showing the structure of the electron tube concerned, further, 100 show the welding part of the glass bulb 5 and a flange 4 among drawing 4 , and, as for 101, the welding part of the glass bulb 5 and a flange 9 is shown.
[0024] The above-mentioned anode electrode 6 consists of a cylinder part in the air and a cone part in which opening 600 was formed, and is a stainless steel electrode of the configuration projected to convex toward the photoelectric surface 16 from glass bulb 5 edge (going to the interior of the glass bulb 5 concerned from the 2nd opening 500). The overall length of this anode electrode 6 is 18mm, and the bore of the opening 600 prepared in this anode electrode 6 is 8mm. In addition, the configuration of this anode electrode 6 is acquired by carrying out press working of sheet metal of the disk plate which was cut down from the stainless plate and which has opening in the center.
[0025] As shown in drawing 5 , the collimator electrode 8 is being fixed to this anode electrode 6 by the predetermined location of that interior through the shield 7. That is, the slot 60 (engagement slot) perpendicularly formed to the direction L of incidence of light (it is in agreement with the direction AX of a tube axis of the glass bulb 5) shown in the wall of this anode electrode 6 at drawing 4 is formed, a shield 7 is in the condition of having made the edge part engaging with this slot 60, and welding immobilization is carried out at this anode electrode 6. Thereby, a shield 7 and the anode electrode 6 concerned are set as this potential. Furthermore, it is in the condition which the opening 700 for this shield 7 to hold the collimator electrode 8 is formed, and inserted the collimator electrode 8 in this opening 700, and this collimator electrode 8 is fixed to the predetermined location in the anode electrode 6 by carrying out welding immobilization of the plane of composition 82 of this collimator electrode 8, and the field by the side of the photoelectric surface of this shield 7. In addition, the area of the opening 700 of a shield 7 is smaller than the area of the photoelectric-surface side opening 80 of the through tube 800 in the collimator electrode 8, and larger than the area of the stem side opening 81 of the through tube 800 in the collimator electrode 8. [ that the collimator electrode 8 should be held ]
[0026] Next, the structure of the cathode electrode 3 in the electron tube concerning this invention is explained using drawing 6 .
[0027] This cathode electrode 3 is an electrode which has a through tube 300, and is in the cross section (area of this through tube 300 defined by the perpendicular flat surface to the direction AX of a tube axis) of this through tube 300 as **** small toward a semiconductor device 14 from the photoelectric surface 16. The edge section 30 equipped with contact side 30a for fixing the cathode electrode 3 concerned to a flange 4 is formed in a part for the point by the side of the photoelectric surface of the cathode electrode 3. The amount of [ by the side of the stem of this cathode electrode 3 ] point has extended toward the semiconductor device 14 in accordance with the wall 502 of the glass bulb 5, as shown in drawing 4 . Therefore, the part projected toward the stem 10 of this cathode electrode 3 is gradually estranged from the wall 502 of the glass bulb 5 toward the photoelectric surface 16 to the stem 10 (the amount of [ by the side of the stem of this cathode electrode 3 ] point is thin toward this stem 10). If it puts in another way, the area S1 of the photoelectric-surface side opening 31 of the through tube 300 in the cathode electrode 3 concerned is larger than the area S2 of the stem side opening 32 of the through tube 300 in the cathode electrode 3

concerned. Furthermore, a part for the point by the side of the stem of the cathode electrode 3 was processed in the shape of [ whose radius of curvature r is 1mm ] a semicircle, and has turned to the tube axis of the glass bulb 5.

[0028] In addition, in this cathode electrode 3, the diameter of 22mm and the stem side opening 32 of the diameter of the photoelectric-surface side opening 31 is 16mm, and that overall length is 6mm. Moreover, the configuration of this cathode electrode 3 is also acquired by carrying out press working of sheet metal of the disk plate which was cut down from the stainless plate and which has opening in the center like the anode electrode 6 mentioned above.

[0029] Even if it can realize structure where this cathode electrode 3 interrupts the wall 502 of the insulating glass bulb 5, to the electron which runs the inside of the vacuum in a well-closed container by constituting the cathode electrode 3 which constitutes an electron lens from above configurations and compares with the former, turbulence of the electron orbit resulting from electrification of the wall 502 of this glass bulb 5 by the stray electron is controlled, and the stable output is obtained. Furthermore, since electrification of the wall 502 of this glass bulb 5 can be controlled effectively, the intermittent discharge (it is a **** when accompanied by luminescence) resulting from this electrification is avoidable. Therefore, the electron tube concerned conquers the fault on the structure where the photoelectric surface 16 emits an electron corresponding to the light generated by this discharge. Consequently, since generating of the false signal (noise) resulting from electroluminescence is controlled from the photoelectric surface 16, S/N at the time of feeble light measurement improves remarkably as compared with the conventional electron tube.

[0030] Next, the structure of the collimator electrode 8 in the electron tube concerning this invention is explained using drawing 7 .

[0031] The collimator electrode 8 is a bell shape stainless steel electrode which has the through tube 800 prolonged toward the stem 10 from the photoelectric surface 16. Through the shield 7 (support electrode), it unites with the anode electrode 6 and this collimation electrode 8 is arranged.

[0032] Usually, while being accelerated with the electron lens which consists of a cathode electrode 3 and an anode electrode 6, it converges the orbit and incidence of electronic e- emitted from the photoelectric surface 16 is carried out to the electronic plane of incidence of a semiconductor device 14. However, if an electron lens is constituted so that the photoelectric surface 16 and a semiconductor device 14 may be made to approach, the path of the electron flow further emitted from the photoelectric surface 16 with an effective diameter of 16mm may be converged on about 1.5mm for example, and incidence may be carried out to a semiconductor device 14, incidence of electronic e- emitted from the circumference part of this photoelectric surface 16 will not be perpendicularly carried out to the plane of incidence of a semiconductor device 14. Thus, that electronic e- carries out incidence to plane of incidence with a predetermined include angle to the perpendicular direction of plane of incidence means that the die length which crosses the field (dead layer) which the electron which reached this plane of incidence does not contribute to the electronic multiplication in a semiconductor device 14 becomes long, i.e., the amount of energy lost in this dead layer becomes large. This degrades the discrimination capacity of the electron number of the electron tube concerned.

[0033] On the other hand, the collimator electrode 8 concerned is emitted from the circumference part of the photoelectric surface 16, and forms electric field which return photoelectron e- which is going to carry out incidence to a semiconductor device 14 aslant in the direction AX (it is in agreement with the direction L of incidence of light) of a tube axis (R> drawing 4 4 reference). Since electronic e- emitted from all the fields within the photoelectric surface 16 (effective diameter of 16mm) will lose energy in homogeneity in a dead layer by this, the discrimination capacity of an electron number of the electron tube concerned is highly maintainable.

[0034] Furthermore, that the above-mentioned collimator electrode 8 should reinforce above-mentioned effectiveness further, as shown in drawing 7 , the cross section (area of this through tube 800 defined by the perpendicular flat surface to the direction AX of a tube axis) of the through tube 800 is small toward the photoelectric surface 16 to the stem 10. If it puts in another way, the area S3 of the photoelectric-surface side opening 80 of the through tube 800 in the collimator electrode 8 is larger than area S4 of the stem side opening 81 of the through tube 800 in this collimator electrode 8.

[0035] Moreover, if reference is made about the relation on the structure of the collimator electrode 8 concerned and the electronic plane of incidence of a semiconductor device 14, area S4 of the stem side opening 81 of the through tube 800 in this collimator electrode 8 is smaller than the area of the electronic plane of incidence of this semiconductor device 14 mentioned later. That is, the direction of the area of the field at which the electron emitted from the photoelectric surface rather than the effective area of the

electronic plane of incidence in a semiconductor device 14 arrives is small. Incidence is carried out in addition to the electronic plane of incidence of a semiconductor device 14, the semiconductor device 14 the very thing concerned is not degraded, or the electron accidentally emitted from other than photoelectric-surface 16 by this does not produce (degradation resulting from electron impact), and unnecessary electrification.

[0036] In addition, when that overall length is 3.5mm, as for the above-mentioned collimator electrode 8, it is desirable that the diameter of the photoelectric-surface side opening 80 of a through tube 800 is 3mm, and the diameter of the stem side opening 81 of this through tube 800 is 2mm (at this time, the area of the stem side opening 81 is set up so that it may become smaller than the area of the electronic plane of incidence of a semiconductor device 14).

[0037] A stem 10 is constituted from a disk plate 13 (covar metal) which plugs up the other end of the stainless steel pipe 12 with which welding immobilization of the end was carried out, and this stainless steel pipe 12 by opening of the member 11 (stainless steel) of the disk configuration which has opening at the core, and this member 11, and the configuration is a convex configuration projected from the edge which has the 2nd opening of the glass bulb 5 toward the photoelectric surface 16. The semiconductor device 14 by which bonding was carried out on this stem 10 (on the disk plate 13) is arranged through the above-mentioned collimator electrode 8 in the photoelectric surface 16 and the opposite side. Furthermore, since the output signal from a semiconductor device 14 is outputted to the exterior of the well-closed container concerned, the lead pin 15 insulated with this stem 10 is being fixed to the disk plate 13.

[0038] Next, the structure of the semiconductor device 14 carried on the disk plate 13 of a stem 10 is explained using drawing 8 and drawing 9 .

[0039] This semiconductor device 14 is installed on the disk plate 13 of a stem 10 so that that electronic plane of incidence 148 may counter with the photoelectric surface 16. The electrode layer 146 which this semiconductor device 14 mentions later is electrically connected with the metal lead pin 15 which inserted in airtightly the through tube 130 prepared in the disk plate 13 by carrying out bonding of the edge of the metal wire 18, respectively. A predetermined electrical potential difference is impressed to the photoelectric-surface side of a semiconductor device 14 through the lead pin 15 and a wire 18 from the external power circuit 910, for example, it is held potential abbreviation-150V. Moreover, the same electrical potential difference as the applied voltage of an electron lens is impressed to the disk plate 13 side of a semiconductor device 14 through a stem 10 from the above-mentioned power circuit 910, for example, it is held potential abbreviation 0V. Thereby, the reverse bias electrical potential difference is impressed to the semiconductor device 14 as a whole.

[0040] In addition, the above-mentioned lead pin 15 is connected to the processing circuit 900 which processes the detecting signal (output current) outputted from a semiconductor device 14 through Capacitor C (refer to drawing 4 ). Moreover, it fills up with the insulating member 17 between the wall of the through tube 130 of the disk plate 13, and the lead pin 15. Furthermore, in the semiconductor device 14 concerned, the aperture of the electronic plane of incidence 148 which receives a photoelectron and is effectively amplified with a predetermined multiplication factor is about 3mm.

[0041] As shown in drawing 8 , in this example, the avalanche photo-diode (henceforth APD) is used as the above-mentioned semiconductor device 14. This APD14 is equipped with the substrate 140 which is the high concentration silicon layer of n mold, and the carrier multiplication layer 141 of p mold is formed by disc-like on this substrate 140 at that central part. It is the outside of this carrier multiplication layer 141, and the guard ring layer 142 which is a high concentration n type layer by the same thickness as this carrier multiplication layer 141 is formed on the substrate 140. Furthermore, on the carrier multiplication layer 141, the breakdown voltage control layer 143 which is a high concentration p type layer is formed. The oxide film 144 and the nitride 145 are formed in the guard ring layer 142 from the circumference part of the breakdown voltage control layer 143 at the **** front-face side. In order to supply anode potential to the breakdown voltage control layer 143, aluminum is vapor-deposited in the shape of a circular ring, and the anode 146 (electrode) is formed. Moreover, this anode 146 and a gap are given and the guard ring layer 142 and the circumference electrode 147 which has flowed are formed in the circumference part.

[0042] In addition, the measuring area (electronic plane of incidence 148) of this APD is the inside part of an anode 146, and the diameter of 3mm is suitable for it. Moreover, as mentioned above, die bonding of this APD14 is carried out on the disk plate 13 through resin 149. The cathode potential of this APD14 is given through a stem 10.

[0043] Specifically, the substrate 140 of APD14 is n+. It is the high concentration single crystal wafer formed by Si of a mold. Thickness is about 500 micrometers and, as for this semi-conductor substrate 140, P

(Lynn) is doped by concentration abbreviation 1019cm-3 as an n mold dopant. In addition, the specific resistance of this semi-conductor substrate 140 is about 0.01 ohm-cm.
[0044] The above-mentioned carrier multiplication layer 141 is a low concentration semi-conductor layer formed by growing epitaxially on the semi-conductor substrate 140 in Si of p mold. Thickness is about 10 micrometers and, as for this carrier multiplication layer 141, B (boron) is doped by concentration abbreviation 1014-1016cm-3 as a p mold dopant. In addition, the specific resistance of this carrier multiplication layer 141 is about one to 100 ohm-cm. The dopant concentration of the carrier multiplication layer 141 is a value to which the depletion layer which spreads from a plane of composition with the semi-conductor substrate 140 reaches the breakdown voltage control layer 143, when the electrical potential difference near breakdown voltage is impressed.
[0045] In addition, in order to hold and carry out epitaxial growth of the good crystallinity in this carrier multiplication layer 141, as for the thickness d of this carrier multiplication layer 141, it is desirable to set up within the limits of about 5 micrometers - about 50 micrometers. Since the heterogeneity of the dopant concentration of the direction of thickness (it is in agreement in the direction L of a tube axis in the condition of having been carried in the stem 10) becomes remarkable when larger than about 50 micrometers, Thickness d will degrade the uniformity of the avalanche multiplication gain over the electron emitted from the photoelectric surface 16 depending on a generation-of-carriers location. On the other hand, since the depletion layer in which Thickness d extends and spreads from the semi-conductor substrate 140 when smaller than about 5 micrometers becomes thin, the gain of APD14 concerned to this electron will be reduced.
[0046] The reason set as about 10 micrometers the above-mentioned thickness d here The maximum range of about 3 micrometers (this electron by which incidence was carried out into APD14) to the inside of the acceleration energy APD 14 of the electron emitted by about 15 keV(s) 3.6eV energy is lost -- ** -- alike -- an electronic-electron hole pair -- every one piece -- generating -- it is because some allowances were taken into consideration to about 3 micrometers of thickness of the avalanche multiplication field mentioned later, respectively in order to press down fluctuation of the gain of APD14 to this electron to minimum.
[0047] The above-mentioned guard ring layer 142 is a high concentration semi-conductor layer formed by carrying out thermal diffusion of the n mold dopant to the periphery of the carrier multiplication layer 141. that thickness of this guard ring layer 142 is the same as that of the thickness of the carrier multiplication layer 141 (about 10 micrometers) -- it is -- as n mold dopant -- P -- the same concentration 1019 [ about ] as the dopant concentration of the semi-conductor substrate 140 -- it is doped by cm-3.
[0048] The above-mentioned breakdown voltage control layer 143 is a high concentration semi-conductor layer formed by carrying out thermal diffusion of the p mold dopant to the surface central field of the carrier multiplication layer 141. That thickness of this breakdown voltage control layer 143 is about 1 micrometer, and B is doped as a p mold dopant by the concentration abbreviation 1019cm-3 [ same ] as the dopant concentration of the semi-conductor substrate 140. The circular electronic plane of incidence 148 counters the photoelectric surface 16, and is exposed to the surface center section of this breakdown voltage control layer 143. In addition, the service area of this electronic plane of incidence 148 is restricted to the area S5 smaller than the area of this electronic plane of incidence 148 by the collimator electrode 8, as shown in drawing 9 . That is, the aperture of the field in which incidence of an electron is possible is actually restricted to about 2mm to being about 3mm, as electronic plane-of-incidence 148 aperture which can receive the electron by which incidence was carried out was mentioned above.
[0049] On most on the surface periphery section of the breakdown voltage control layer 143 located in the periphery of the electronic plane of incidence 148, and the whole front face of the guard ring layer 142, two kinds of insulating layers 144 and 145 carry out a laminating one by one, and are formed. An insulating layer 144 is the insulating thin film formed with the oxide of Si. The thickness of this insulating layer 144 is about 200nm. An insulating layer 145 is the insulating thin film formed with the nitride of Si. The thickness of this insulating layer 145 is about 50nm.
[0050] In addition, in case the guard ring layer 142 and the breakdown voltage control layer 143 are formed, in order to hold the crystallinity of the carrier multiplication layer 141 good, an insulating layer 144 oxidizes the surface field of the carrier multiplication layer 141 beforehand, and is formed. Moreover, in case the photoelectric surface 16 is formed, in order not to degrade the semi-conductor property of the carrier multiplication layer 141, the guard ring layer 142, and the breakdown voltage control layer 143, an insulating layer 145 is made to deposit on an insulating layer 144, and is formed.
[0051] The circular ring-like ohmic electrode layer 146 is formed on the above-mentioned insulating layer 145, and it is in contact with the surface periphery section of the breakdown voltage control layer 143 in

accordance with the side attachment wall of insulating layers 144 and 145. This ohmic electrode layer 146 is the metal thin film formed with aluminum (aluminum), and has good ohmic contact nature to the breakdown voltage control layer 143.

[0052] In addition, as mentioned above, a predetermined electrical potential difference is impressed through the conductive lead pin 15 from the external power circuit 910 by the bonding of a wire 18, for example, this ohmic electrode layer 146 is held at the negative potential which is -150V. Moreover, the semi-conductor substrate 140 is installed on a stem 10, and a predetermined electrical potential difference is impressed to it from the external power circuit 910, for example, it is held at the grand (GND) potential of 0V. Thereby, it is n+. The semi-conductor substrate 140 and p+ of a mold A depletion layer is generated as an avalanche multiplication field by between [ 141 ] the breakdown voltage control layers 143 of a mold (i.e., a carrier multiplication layer).

[0053] Thus, 0V (ground potential) are impressed to -15kV and the anode electrode 6 from the external power circuit 910 at the photoelectric surface 16 of the constituted electron tube, and the cathode electrode 3. At this time, the cathode electrode 3, the anode electrode 6, and the collimator electrode 8 form an electron lens, and it is made to converge to the diameter of 1.5mm smaller than the area of the stem side opening 81 of the through tube 800 in the collimator electrode 8, and they carry out incidence of the electron flow emitted from the photoelectric surface 16 with an effective diameter of 16mm to the electronic plane of incidence 148 of APD14. As mentioned above, -150V are impressed to the anode 146 of APD14 so that about 50 times as many avalanche multiplication gain as this may be acquired. Moreover, as for the cathode (the stem 10 is functioning as this cathode) of this APD14, 0V are given.

[0054] Here, if light carries out incidence through the plane-of-incidence plate 1, an electron will be emitted into a vacuum from the photoelectric surface 16. It converges, this emitted electron has the energy of 15keV, and incidence is carried out to the electronic plane of incidence 148 of APD14 while being accelerated with an electron lens. this electron by which incidence was carried out to the electronic plane of incidence 148 loses 3.6eV energy within APD14 -- ** -- since it is alike and generates one electronic-electron hole pair at a time -- this first multiplication process -- about 4x103 twice (electron irradiation gain until it arrives at the avalanche multiplication field of this incidence electron) -- extent multiplication is carried out. Furthermore, avalanche multiplication gain until these carriers pass through an avalanche multiplication field and reach the semi-conductor substrate 140 is about 50. Thereby, the gain of the secondary electron [ as opposed to an incidence electron as a whole ] of APD14 is 2x105. Extent is reached.

[0055] Since the multiplication factor of the first rank is high figures triple [ about ] compared with 4000 and the conventional electron tube as mentioned above in the electron tube concerning this invention, very good detection of S/N is possible. Actually, artificers checked that it could discriminate from the input electron number (it is convertible into the number of incident light children) from which it was not able to discriminate with the electron tube concerning this invention in the conventional electron tube, when very feeble pulsed light carried out incidence and an average of 4 electronic extent was emitted from the photoelectric surface. In case such a property acquired with the electron tube concerning this invention observes quantitatively the fluorescence emitted from the living body minute amount matter, it is very effective.

[0056] In addition, even if it impresses [ 16 ] high pressure called -15kV of photoelectric surfaces, it is important that discharge does not occur within the electron tube. With discharge here, feeble discharge which does not do harm is also included not only in the intense discharge which destroys the photoelectric surface 16 and a semiconductor device 14 but in these. The light which also generated feeble discharge by this discharge in many cases with luminescence especially is because a false signal (noise) is generated as return and a result in the photoelectric surface 16 in the path of arbitration.

[0057] The electron tube concerning this invention has set long smoothly the edge surface distance (the die length of the direction AX of a tube axis of this glass bulb 5) of the glass bulb 5 which is the insulator which maintains high pressure as 24mm like as much as possible. Moreover, a part for the point of the cathode electrode 3 which electric field concentrate and serves as a trigger of discharge is separated from the wall 502 of the glass bulb 5 to which potential becomes unstable by electrification (refer to drawing 2 and drawing 4 ). That is, the cathode electrode 3 has the configuration to which the outer diameter becomes small toward a semiconductor device 14 from the photoelectric surface 16. Furthermore, the amount of [ of the cathode electrode 3 ] point is considering as the cross-section configuration of a hemicycle with a radius of curvature of 1mm, in order to avoid concentration of electric field (refer to drawing 6 ). By the above configuration, the electron tube concerning this invention has realized structure for avoiding the feeble discharge which is easy to generate when impressing the high voltage.

[0058] The electron tube concerning this invention is bringing the cathode electrode 3 and the anode electrode 6 of each other close further paying attention to the time amount property. That is, the cathode electrode 3 has the configuration projected toward the anode electrode 6, and this anode electrode 6 has the configuration projected toward the cathode electrode 3. This is for securing the field strength which fully accelerates the electron emitted from the photoelectric surface 16 by making each electrodes 3 and 6 approach. Moreover, making electrodes 3 and 6 approach in this way is based on the rule of thumb of being hard to generate inter-electrode vacuum discharge compared with edge surface discharge of an insulating material, and, as for this distance, pressure-proofing is not actually restricted. Furthermore, the semiconductor device 14 is also brought close to the photoelectric surface 16 from the viewpoint of a time amount property for the purpose of shortening the mileage of the photoelectron from the photoelectric surface 16 to a semiconductor device 14, and the transit time. According to such structures, transit-time fluctuation from the photoelectric surface 16 to a semiconductor device 14 was made small, and the time amount property of 50ps (picosecond) extent is realized.
[0059] As mentioned above, it is effective in removing the effect on the electron which runs the inside of the vacuum of the glass bulb 5 which consists of an insulating ingredient again to make the cathode electrode 3 and the anode electrode 6 approach. That is, this glass bulb 5 is charged for the electron which strays the inside of a vacuum, or ion, and can take various potentials. Therefore, in response to the effect according that the wall 502 of the glass bulb 5 is the structure exposed to the electron orbit to this electrification, the output current becomes unstable, and, as for the electron tube concerned, a drift property deteriorates.
[0060] In the electron tube concerning this invention, while making some cathode electrodes 3 project toward the anode electrode 6 as mentioned above, it has the structure where each electrodes 3 and 6 were made to approach, by making these some anode electrodes 6 project toward the cathode electrode 3. the stem side opening 32 of the through tube [ in / when putting in another way, as it was shown in drawing 10 / the cathode electrode 3 ] 300, and the opening 600 in the anode electrode 6 -- each is located in the building envelope 503 of this glass bulb 5 defined by the 1st opening 500 and 2nd opening 501 of the glass bulb 5. Thus, since the wall 502 of this glass bulb 5 directly exposed from the cathode electrode 3 by constituting to the electron which faces to the anode electrode 6 is restricted to the minimum (field shown all over [ L2 ] drawing), the output current acquired through the lead pin 15 is stabilized by it.
[0061] Moreover, since the forward electrical potential difference is impressed to the electronic plane of incidence 148 (-150V), the collimator electrode 8 (0V) can control the ion which returns from the electronic plane of incidence 148 to the photoelectric surface 16. The ion controlled here is gas of a molecule and the shape of an atom which was sticking to the electronic plane of incidence 148 of a semiconductor device 14, and with the primary electron which carried out incidence, an electron is calculated and it is just ionized. Since the reverse bias for a cation is impressed between the electronic plane of incidence 148 and the collimator electrode 8, these ion cannot pass through this collimator electrode 8, and cannot return to the photoelectric surface 16.
[0062] Thus, the property that ion does not return to the photoelectric surface 16 is important. That is, in the electron tube concerned, it is because the ion which returns to the photoelectric surface 16 will return with the same high energy and a destructive damage is given to the photoelectric surface 16, since the high voltage is impressed between the photoelectric surface 16 and a semiconductor device 14. Therefore, when the ion which returns to the photoelectric surface 16 cannot be controlled, the life of the photoelectric surface 16, i.e., the life of the electron tube concerned, will be shortened remarkably.
[0063]
[Effect of the Invention] As mentioned above, according to this invention, it is small as the edge surface distance of the glass bulb which is an insulating ingredient is taken enough and the outer diameter of a cathode electrode goes to a semiconductor device. Since electrification of this glass bulb is suppressed and generating of the intermittent discharge between this cathode electrode and a glass bulb can be avoided by this configuration, it becomes possible to stabilize and impress an electrical potential difference high enough to the electron tube concerned.
[0064] Moreover, since this electron and the wall are covered for the wall of a glass bulb with this each electrode, a time amount property is good, and, as for this glass bulb, the effect of electrification can also realize actuation in which it was hard coming to receive and the long time of the electron tube concerned was stabilized so that an anode electrode may be made to approach a cathode electrode and the part directly exposed to the electron which runs this each inter-electrode one may be made into the minimum.
[0065] Furthermore, there are an electron emitted by the function of a collimator electrode from the photoelectric surface and effectiveness that the electron tube which has the high discrimination capacity of

an electron number is obtained since incidence is carried out at right angles to a semiconductor device.

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[Translation done.]

* NOTICES *



1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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DRAWINGS

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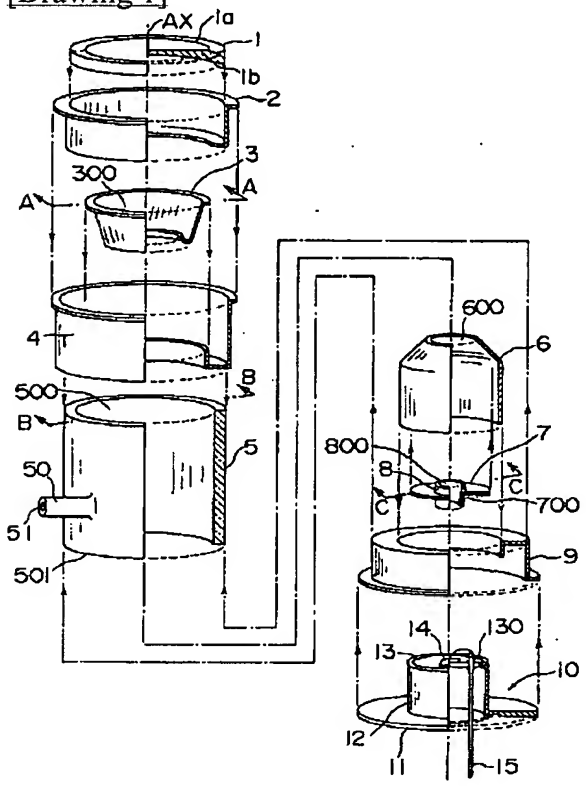
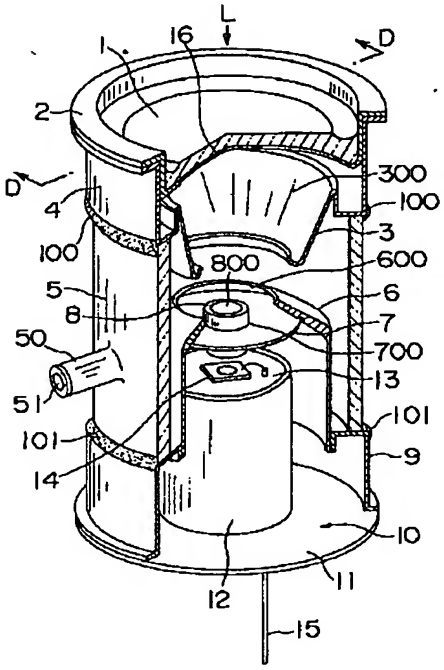
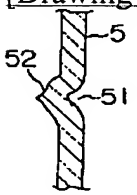
[Drawing 1]



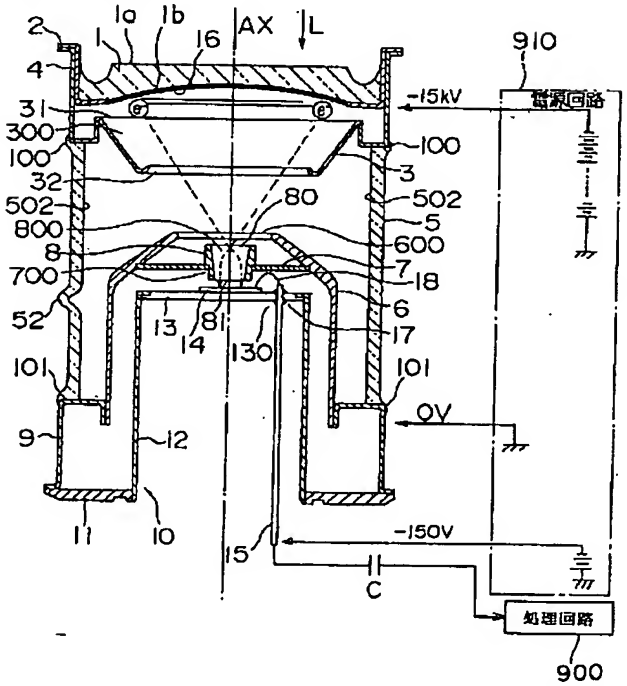

[Drawing 2]



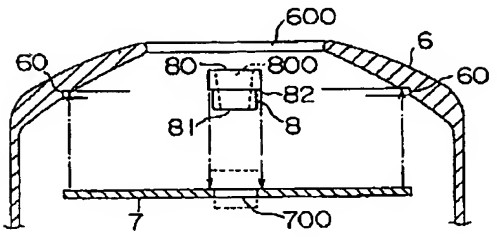

[Drawing 3]



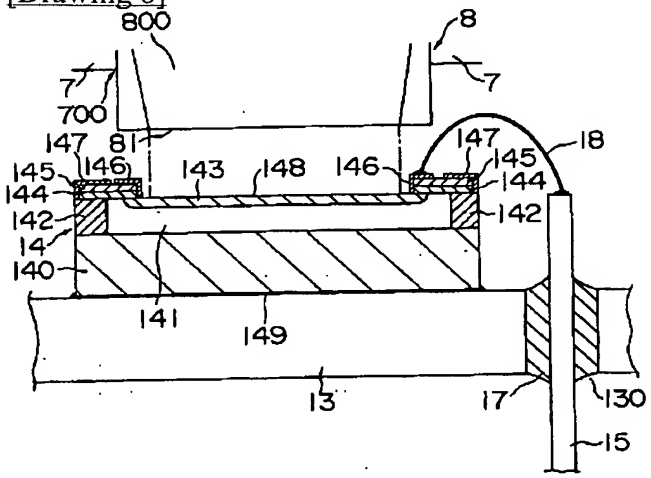

[Drawing 4]



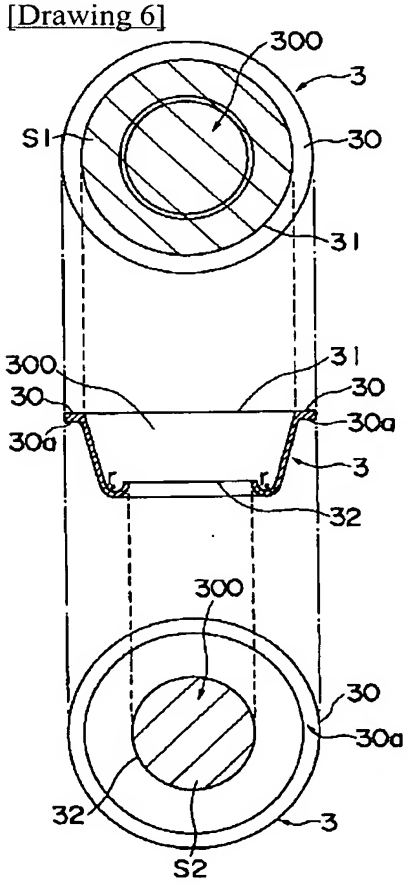

[Drawing 5]



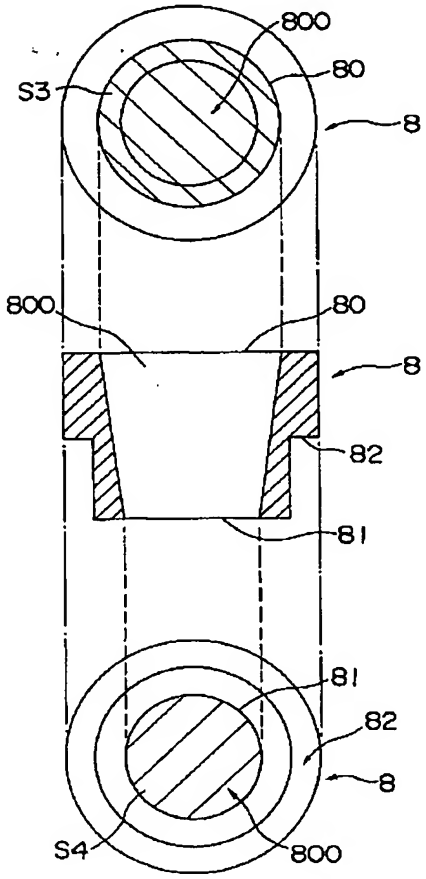

[Drawing 8]



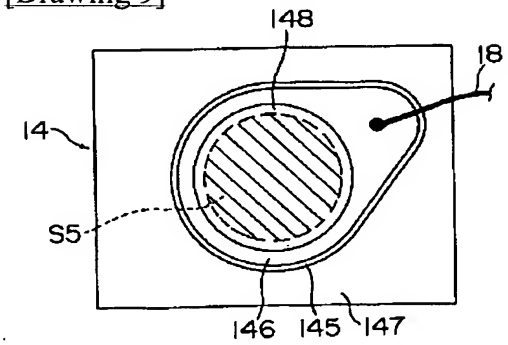

[Drawing 6]



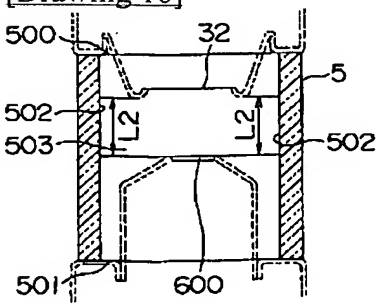

[Drawing 7]




[Drawing 9]




[Drawing 10]




[Translation done.]